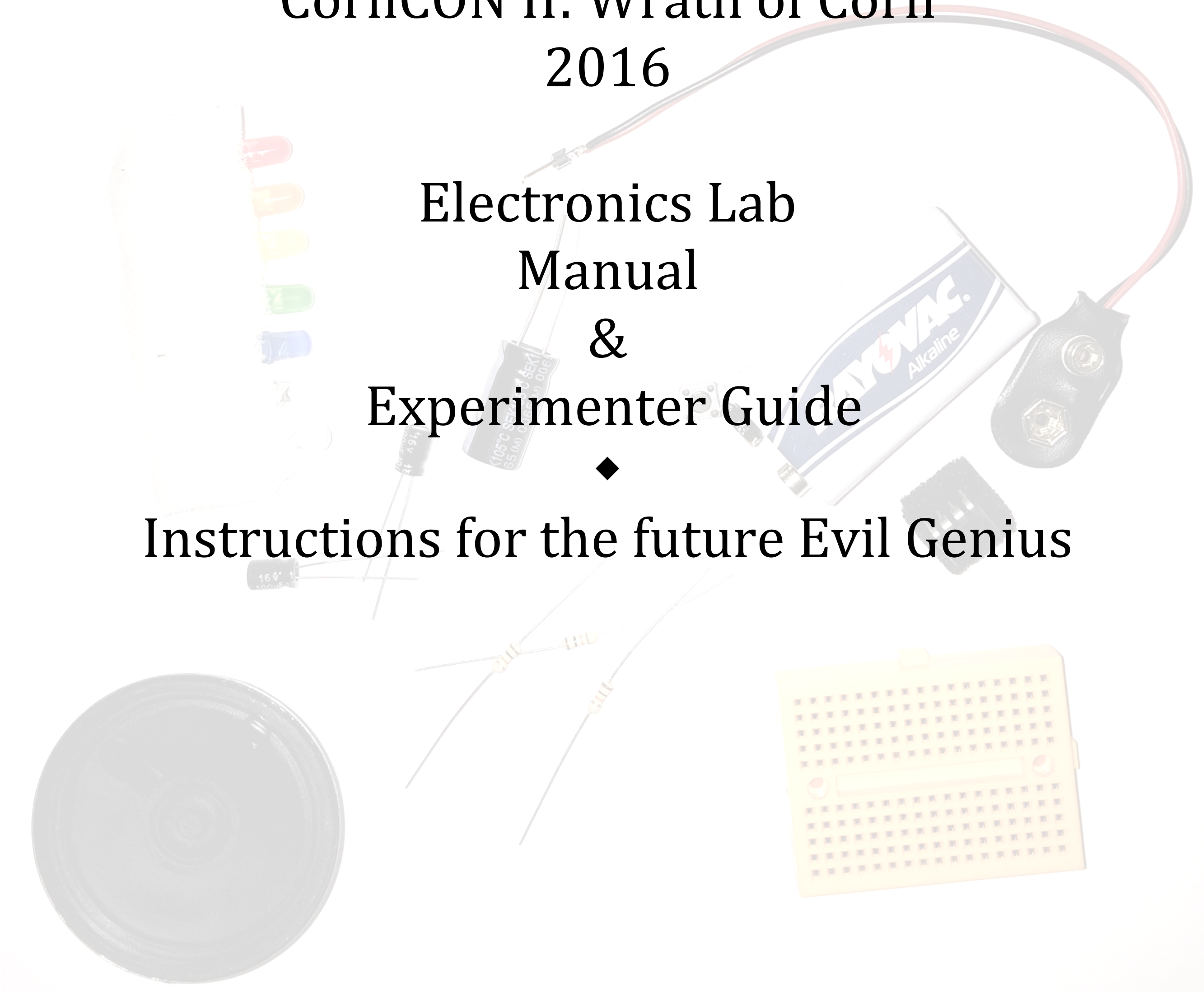
CornCON II: Wrath of Corn
2016



Electronics Lab Manual & Experimenter Guide

◆

Instructions for the future Evil Genius

Project Kit and Manual provided by the Quad Cities Cyber Security Alliance

First Edition

WARNING:

This kit contains small parts and may present a choking hazard to children under three.
An adult should supervise access to and the use of this kit if small children are in the area.

Use of this content may spark creativity and development of lifelong skills.

Resistance is futile.

Coloring book excerpt by Lady Ada – Coloring book illustrations by Robert Ullman
Download the complete coloring book at:
http://adafruit-coloringbook.s3.amazonaws.com/coloringbook_9-17-2012.pdf

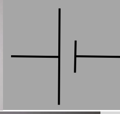
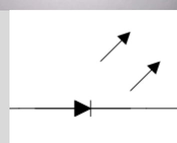
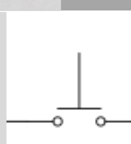
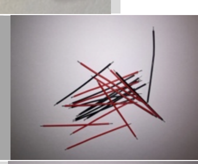
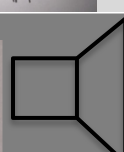
Figure 2,4,5,6,7,8,9,10,11, all backgrounds kit photos and schematics by Eric Andresen
Figure 1 by Armstrong1113149 and 3 by Inductive load are public domain images

Tested by Jon Williams

Special Thanks to all that reviewed and proofed this manual and the Oxford comma.

TABLE OF CONTENTS

Parts List

Quantity	Description	Picture / Symbol	Notes
1	9 Volt Battery	 	Supplies power for projects
1	Battery Clip		Attaches battery to Experimenter board
1	Experimenter Board		Base for projects and attach parts together
7	Light Emitting Diodes	 	Colorful Lights
1	555 Timer Integrated Circuit		Semiconductor timer
1	Normally Open Pushbutton Switch	 	Press to power project
20	Jumper Wires		10 Red wires and 10 Black wires to connect parts together
1	Component Card		Resistors and Capacitors for use in experiments
1	Speaker	 	Used to create sound from your experiment

Introduction

Congratulations, with this kit you are taking the first steps on your journey to unlocking a world of creative genius. Using this kit you will learn basic electronic concepts, identification of kit components, reading electronic diagrams, and most importantly how to build a number of projects.

Today electronics surrounds us everywhere; telephone, television and computers all rely on electronics. Knowing a little about how it works is a valuable skill.

Electronics is the branch of physics and technology concerned with the design of circuits, and movement of electrons. This kit was designed to help you learn concepts by completing a number of experiments. Experimentation is the way we make discoveries and by using this kit you can discover a life-long appreciation for electronics in the world around you.

Electronic Concepts

A 9-volt battery powers this kit. Electricity is often described as a fluid. Oliver Lodge, a great physicist, once had the idea that electricity was a fluid. He described this in his drainpipe theory. Electricity isn't a fluid, but this description will help you understand his ideas about the subject.

Water has a source and has to go somewhere. It flows through pipes at a given speed and in some amount you can measure. If something gets stuck in a pipe it slows the water down or stops it flowing. A valve can even switch the flow of water on or off.

All of these ideas about water apply to electricity. The source of the electricity in this kit is the battery. You turn the electricity on and off with a switch. The pipes that carry electricity are called conductors. All experiments will be connected to a source of power marked with a (+) symbol. They also have a return path or drain marked with a (-). Power in the experiments will flow around a circuit. We use resistors to slow the flow of electrons inside circuits.

How fast the electricity flows is a result of the difference in pressure inside the pipe. In circuits we call this pressure potential. Potential is measured in volts after the Italian scientist Alessandro Volta. The battery included in the kit has a potential of 9 Volts. The rate of electrical flow is called Current. The unit of measurement for current is the Amp named after the French physicist Andre Ampere.

The voltages and current used in all of the experiments are considered to be low voltage, low current and safe. Touching the wires with your hands will not result in any injury. To ensure safety, always connect the battery after you complete the construction of your experiment. For added safety we have included a switch that requires you press a button to power your project.

Using a Breadboard

The breadboard is the very foundation of electronics experimenting. It provides the base for your project. It gets its name from the polished wooden boards used to cut bread. In the past, experimenters drove screws or nails into a board. They had to use solder, a metal you can melt, to assemble the project. Today, modern breadboards help us with this task. It is much safer and easier because modern breadboards do not require you to solder parts together. Solderless Breadboards makes it faster and easier to assemble projects and make changes.

Figure 1 - This 1920s TRF radio manufactured by Signal was constructed on a wooden breadboard.

The breadboard in this kit contains 10 rows marked with letters and 17 columns marked with numbers. Each breadboard has 170 places to plug things in. Each wiring point can be identified with its location. The photos in this manual were taken with location J1 in the upper left of the board and A17 in the lower right.

Since no soldering is required you can connect and replace parts quickly. You might hear it called a strip board as well because the board is made up of 17 strips along the top and 17 strips along the bottom that connect all of the rows in the upper and lower part of a column together. Look at the fourth column along the top in red. If you connect a part to any of these holes F4 to J4 you can connect another part by simply plugging the part you want to add into one of the holes remaining.

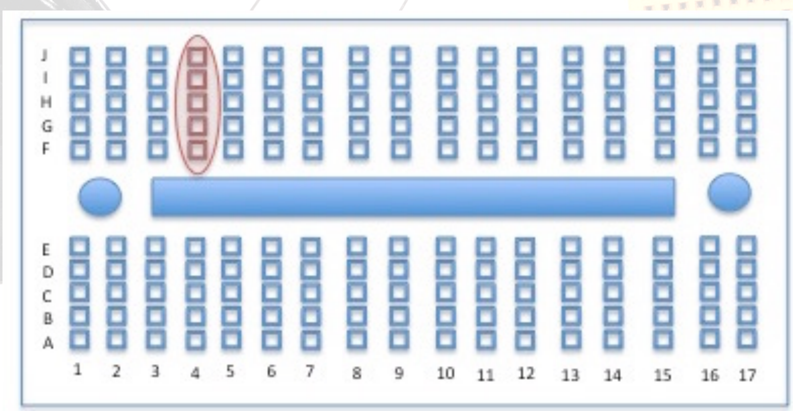


Figure 2 - 170 point breadboard

Identifying Components

All of the parts in this kit appear in photos in the parts list to help you identify them. A few parts will require some special explanation. All materials fall into one of three categories. Materials that allow electrons to travel through them are called **conductors**. Materials that do not allow electrons to travel through them are called **insulators**. This kit contains jumper wires that are conductors. The jumpers are coated with plastic insulation to prevent them from accidentally connecting with other parts. The Light Emitting Diodes and the 555-timer integrated circuit fall into a special category of material called **semiconductors**. Semiconductors are not a conductor or an insulator, falling somewhere in-between.

Your kit contains a foam block that stores seven LEDs and a component card containing the other parts you will use in your experiments. This card contains two kinds of parts **Resistors** and **Capacitors**.

Light Emitting Diodes (LED)

If you look at an LED you will find one leg is longer than the other. The longer leg is on the side we call the **Anode**. The shorter lead is on the side we call the **Cathode**. The Cathode side also has a flat spot as shown in figure 3. The positive (+) side of the battery should always be connected to the Anode and the ground (-) side of the battery should connect to the Cathode unless otherwise shown.

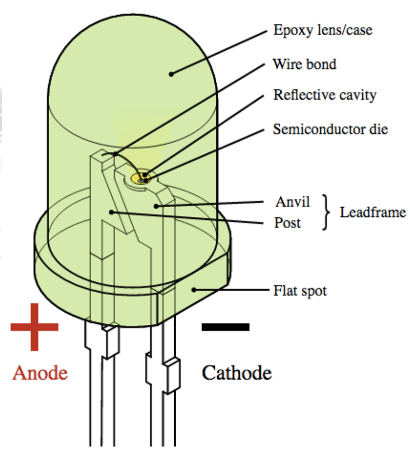


Figure 3 - Parts of an Light Emitting Diode

LEDs physically look like the picture in figure 3, but when you see them on an electronic diagram (called a schematic) you will see the symbol as it appears in figure 4. Schematic diagrams are often used to show how parts are connected together to make a circuit.

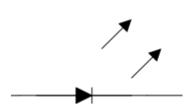


Figure 4 - LED Schematic Symbol

Resistors

Resistors, like rocks in a stream, provided resistance to the flow of electrons as they travel through a circuit. Resistors have two leads; one to allow electrons to flow in and one to allow electrons to flow out. If you connect an LED directly to a battery, the rush of current would be so strong it would damage the LED. In each of our experiments you will find a resistor in line or in "series" with the LED to slow the flow of electrons, protecting the LED from damage.

Resistors come in a variety of sizes, each measured in units of **ohms**. This measurement is named after the German scientist George Simon Ohm who developed standards for measuring resistance. The Ohm is the standard unit of measurement for the resistor and resistance is expressed using the Omega symbol Ω or the letter R. Resistors that offer little resistance will have a lower value than those which offer a high resistance.

Your kit contains three 1,000Ω Resistors. We use shorthand to express thousands of Ω's using the symbol KΩ or KR. A 1,000Ω resistor is 1KΩ or 1KR. We will use 1KR in this lab manual. Your kit also contains a 4.7KR and a 47KR. Resistors appear in schematics using the symbol in figure 5.

Figure 5 - Resistor Schematic Symbol

Resistors are marked using a four-band color code that shows their value. This kit contains three 1K resistors are marked with the bands BROWN, BLACK, RED, and GOLD, one 4.7K resistor marked YELLOW, VIOLET, RED, and GOLD and one 47K resistor marked YELLOW, VIOLET, ORANGE, and GOLD. A card is included in the kit to explain the Resistor color code.

If you are color blind, ask for assistance in reading the values of resistors and someone will help you. Today Smartphone applications are available that take a photo of a resistor and display their values but learning the color code is useful if you are able and plan to spend time around resistors.

Capacitors

Capacitors act like a diaphragm, expanding or contracting to store electric energy as circuit conditions change. You can imagine a membrane inside of the capacitor that stretches or shrinks like a water balloon as the pressure in the circuit acts on the membrane.

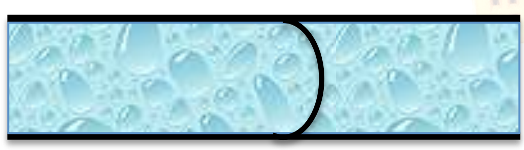


Figure 6 - Capacitor charging

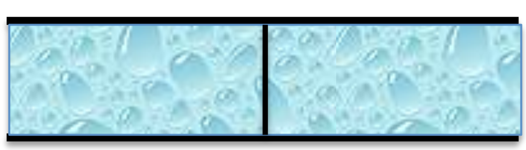


Figure 7 - Capacitor discharged

Capacitance is measured in **Farads** after the English scientist Michael Faraday. The unit of measure for capacitance is the "Farad" symbolized by the letter f. A farad is a very large value of capacitance so we usually express farads in terms of "micro-farads" or uf. 1uf is .000001 farads.

Your kit contains seven capacitors; two 10uf, two 1uf, one 22uf, one 33uf and one 470uf. The values appear in print on the side of the capacitors. Some of the capacitors are "polarized" meaning you need to pay attention to which end you connect to power or ground. Capacitors that are polarized have a white stripe on one side and may have a long lead and a short lead. The longer lead should always be connected to power or the positive end of a connection and the short lead should be connected to ground. Connecting polarized capacitors incorrectly may cause them to swell or pop open with a loud bang. Once they pop open they can no longer be used. Larger value capacitors will charge and discharge slowly when compared to the smaller values, just as it would take longer to fill or empty a large balloon when compared to a small one. The largest Capacitor on the component card has the largest value of 470uf.

Once charged with electricity capacitors can store this charge a long time. Voltage values in this kit are low so you do not need to discharge them for safety. Touching them would be no different than touching the battery terminals. Outside this project voltages can be dangerous, so be sure to work with an adult who knows what they are doing around capacitors outside of this kit.

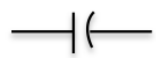


Figure 8 – Capacitor Schematic Symbol

Integrated Circuits

Your kit includes an integrated circuit (IC) called the 555-timer. As the electronic industry developed, we learned that engineers needed to wire together the same circuits over and over, so instead of building the same circuits over and over out of large parts, it was discovered these circuits could be miniaturized and put into a small package prebuilt so engineers could add common features to their products. The 555-timer is one of these circuits. Engineers commonly had a need to time things like alarms that go off when your refrigerator is left open longer than a specified time, or unlocking a door for so many seconds when a button is pushed, or keeping a television or radio on until you fall asleep.

According to the Semiconductor Museum, the 555-timer is one of the most common ICs used in the electronics industry, selling over a billion units each year[1]. The 555-timer includes 25 transistors, 2 diodes and 15 resistors on a silicon chip installed in a plastic package. This package has eight electrical connections you access through wires called pins. ICs come in a lot of different standard sizes measured by the number of pins used to connect the IC to your own circuit. Because pins appear on both sides of the package, the package is called "Dual Inline Pins" or "DIPs". The timer is in an 8-pin DIP package. The pins on the package are numbered one to eight and the first pin is identified with a small dot near pin 1.

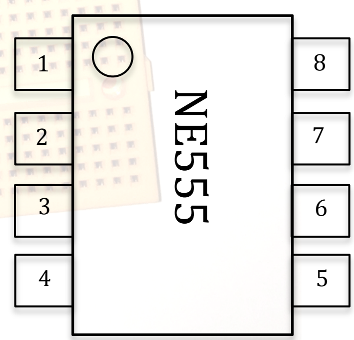
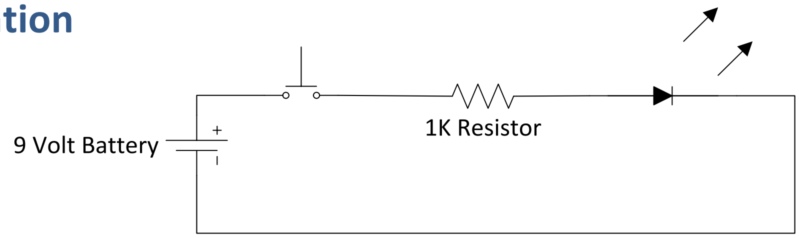


Figure 9 – DIP Pin numbering

[1] http://www.semiconductormuseum.com/Transistors/LectureHall/Camenzind/Camenzind_Page2.htm

Experiment #1 - Illumination Station

The Illumination Station experiment will teach you how to work with Light Emitting Diodes.



Construction Notes: Be sure to include a 1KR in series with the LED to protect the LED from damage. The momentary switch will provide protection ensuring that power is only applied after your circuit has been constructed.

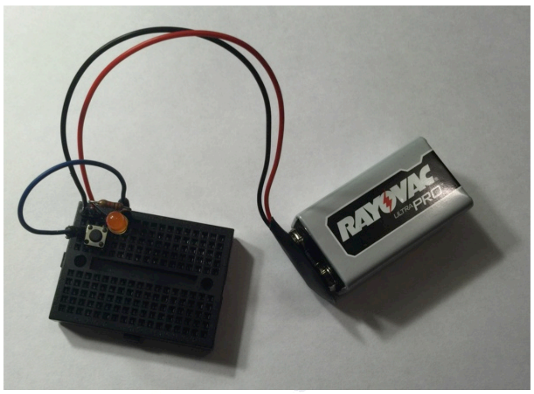


Figure 10 - Photo of Experiment One

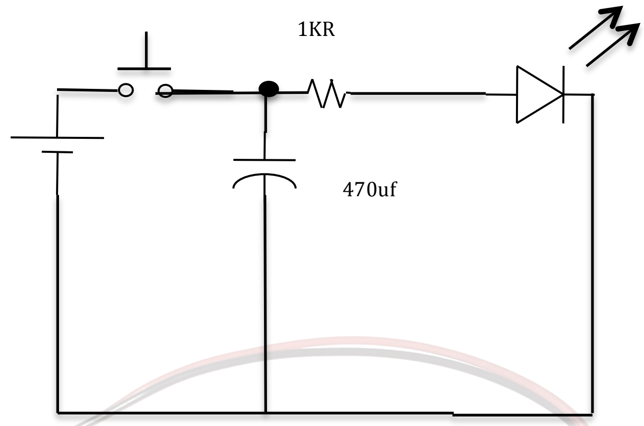
Construction Checklist

- ☐ Disconnect the battery from the clip for safety.
- ☐ Connect the red lead from the battery clip to J2 and the black lead to J1
- ☐ Connect the four legs of the momentary switch to I2, I3, (G2 or)F2 & (G3 or)F3
- ☐ Connect a 1K Resistor between J4 and J5
- ☐ Connect the LED Anode to H5 and Cathode to H6
- ☐ Insert a jumper wire between G1 and J6 connecting the Cathode to the ground side of the battery
- ☐ Connect the battery to the battery clip
- ☐ Press the button

The LED should light when the button is pressed. If the LED does not light when the button is pressed, double-check all of the above connections.

Variations: Once constructed you can try a number of variations to this circuit. If you replace the switch with a jumper between F2 & F3, what effect does it have? What happens to the brightness of the LED if you insert an LEDs Anode at F5 and Cathode at F6? What happens to the brightness of the LED if you add another LED Anode at G5 and Cathode at G6? Why do you think the brightness changes?

Experiment #2 – Fade to Black



In this experiment you will learn the impact that a Capacitor has on a circuit by inserting a capacitor into the circuit you started in Experiment #1.

If you have ever unplugged a power supply from equipment and noticed the power LED remained lit for some time you have seen the effect of capacitance. Capacitors store a charge. The effect is the light fades out instead of just going black.

After building this circuit press the button, release it and count the seconds the LED remains on.

If you have not broken down Experiment #1 you can make this circuit with a small modification. Just insert the 470uf Capacitor, connecting the positive (+) end to F4 and the negative end (-) to F6.

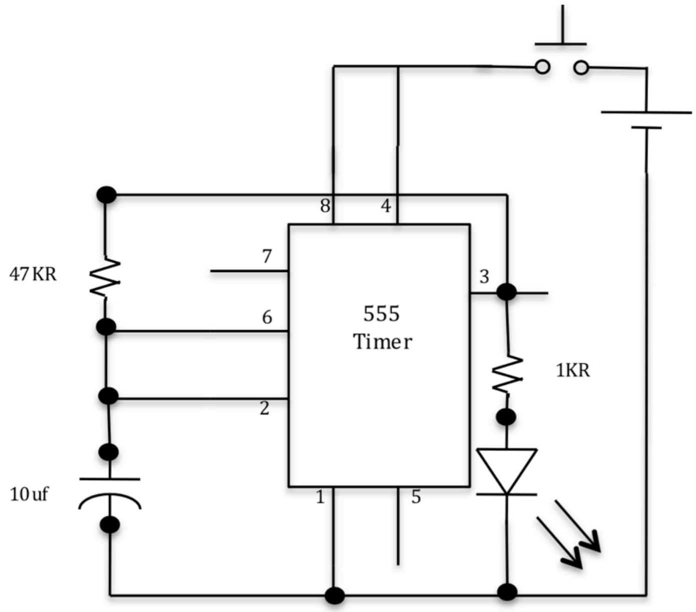
Construction Checklist

- ☐ Disconnect the battery from the clip for safety.
- ☐ Connect the red lead from the battery clip to J2 and the black lead to J1
- ☐ Connect the four legs of the momentary switch to I2, I3, (G2 or) F2 & (G3 or) F3
- ☐ Connect a 1K Resistor between J4 and J5
- ☐ Connect the LED Anode to H5 and Cathode to H6
- ☐ Connect the 470uf Capacitor from F4 (+) and F6 (-)
- ☐ Insert a jumper wire between G1 and J6 connecting the Cathode to the ground side of the battery
- ☐ Connect the battery to the battery clip
- ☐ Press the button

The light should come on when the button is pressed and stay on for several seconds, fading out instead of just going dark. When the button is pressed, the capacitor is charging. The LED will discharge the capacitor when the button is released. How many seconds does the LED stay on when you release the button?

Experiment #3 - Warning Signal

The Warning Signal Circuit is handy if you need to flash a warning or alert signal. It can be used as a fake alarm indicator or when the commissioner needs to signal you in Gotham. It also happens to be a pretty good way to learn how to use Integrated Circuits in your projects.



Construction Checklist

- ☐ Disconnect the battery from the clip for safety
- ☐ Connect the red lead from the battery clip to J2 and the black lead to J1
- ☐ Connect the four legs of the momentary switch to I2, I3, F2 & F3
- ☐ Insert a jumper wire between J4 and J6

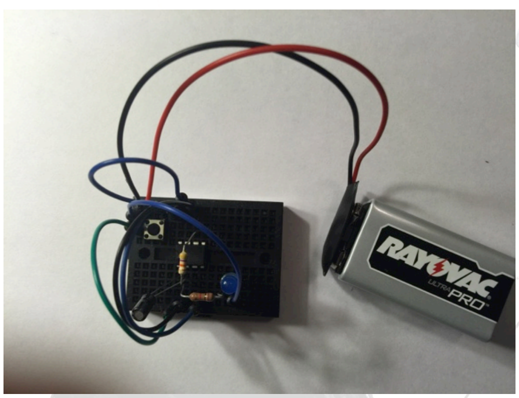


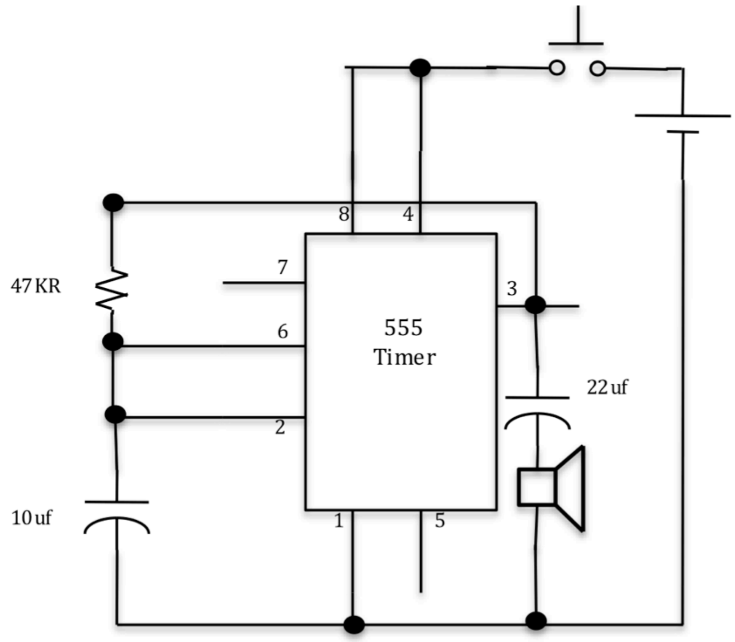
Figure 11 - Photo of Experiment Two

- ☐ Insert the 555 timer oriented so Pin 1 is inserted into E6 and Pin 8 is inserted into F6
- ☐ Insert a jumper wire between I6 and A9 to connect IC pins 8 and 4
- ☐ Insert a jumper wire between J8 and A7 to connect IC pins 6 and 2
- ☐ Insert a 47K resistor between G8 and D8 to connect IC pins 6 and 3
- ☐ Insert a 10uf Capacitor between D6 and D7 taking care to orient the shorter ground lead into D6 and the longer positive lead into D7
- ☐ Insert a 1K resistor between C8 and B12
- ☐ Insert the longer Anode lead of an LED into D12 and the shorter Cathode lead into D13
- ☐ Insert a jumper wire between E13 and I1
- ☐ Insert a jumper wire between G1 and A6
- ☐ Connect the battery to the battery clip
- ☐ Press the button.

The LED should flash when the button is pressed. If the LED does not flash when the button is pressed, double-check all of the above connections. Read experiment #4 before disassembly.

Experiment #4 - Ticking Time Bomb

This circuit is a variation on Experiment #2. If you replace a resistor and LED with a capacitor and a speaker, instead of turning a light on and off the circuit can make a ticking sound at the same rate as the LED - the sound of a ticking time bomb! If you have not disassembled project #2 you can simply replace the resistor at C8 and C12 with a 22uf Capacitor taking care to connect the shorter ground lead to C12, and replace the LED at D12 and D13 with the speaker leads. If you have already disassembled the project, full construction details are included below.



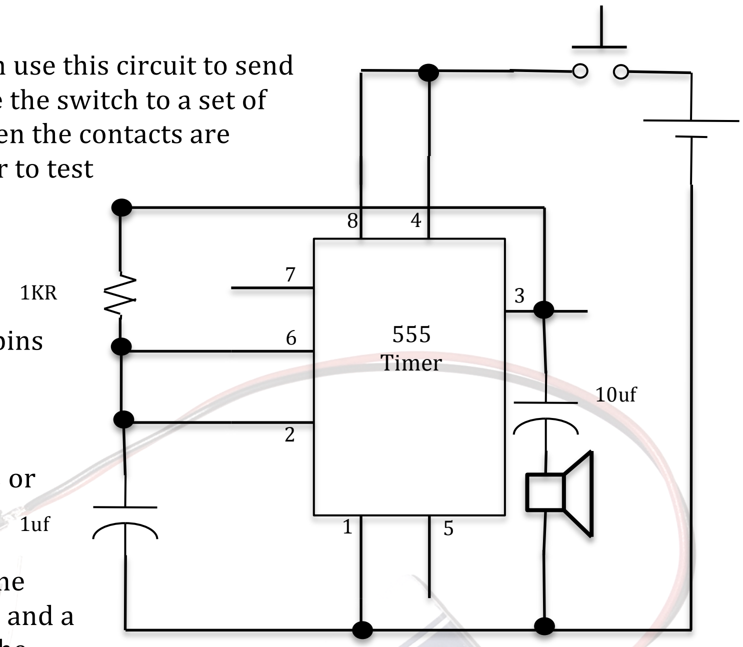
Construction Checklist

- ☐ Disconnect the battery from the clip for safety
- ☐ Connect the red lead from the battery clip to J2 and the black lead to J1
- ☐ Connect the four legs of the momentary switch to I2, I3, F2 & F3
- ☐ Insert a jumper wire between J4 and J6
- ☐ Insert the 555 timer oriented so Pin 1 is inserted into E6 and Pin 8 is inserted into F6
- ☐ Insert a jumper wire between I6 and A9 to connect IC pins 8 and 4
- ☐ Insert a jumper wire between J8 and A7 to connect IC pins 6 and 2
- ☐ Insert a 47K resistor between G8 and D8 to connect IC pins 6 and 3
- ☐ Insert a 10uf Capacitor between D6 and D7 taking care to orient the shorter ground lead into D6 and the longer positive lead into D7
- ☐ Insert a 22uf capacitor between C8 and C12 taking care to connect the shorter ground lead into C12
- ☐ Insert the speaker at D12 and D13
- ☐ Insert a jumper wire between E13 and I1
- ☐ Insert a jumper wire between G1 and A6
- ☐ Connect the battery to the battery clip
- ☐ Press the button

The speaker will tick like a ticking time bomb when the button is pressed. If the speaker doesn't start ticking when the button is pressed, double-check all of the above connections. Read experiment #5 before disassembly

Experiment #5 – Tone Generator/Alarm

This circuit can be a lot of different things. You can use this circuit to send coded messages using Morse code or you can wire the switch to a set of contacts and use the circuit to sound an alarm when the contacts are closed. You can also use it as handy tone generator to test speakers or other sound related projects.



This circuit is a variation on Experiment #3. By changing the resistor and capacitor connected to pins six and two the timing of the circuit changes. Using a smaller resistor and capacitor changes the sound from a ticking time bomb to a steady tone like that used to send coded messages or an alarm.

The timing of the circuit is adjusted by replacing the 47K resistor and 10uf capacitor with a 1K resistor and a 1uf capacitor to change the timing of the circuit. The resistor and LED used in Experiment #2 and replaced with a capacitor and speaker.

Construction Checklist

- ☐ Disconnect the battery from the clip for safety
- ☐ Connect the red lead from the battery clip to J2 and the black lead to J1
- ☐ Connect the four legs of the momentary switch to I2, I3, F2 & F3
- ☐ Insert a jumper wire between J4 and J6
- ☐ Insert the 555 timer oriented so Pin 1 is inserted into E6 and Pin 8 is inserted into F6
- ☐ Insert a jumper wire between I6 and A9 to connect IC pins 8 and 4
- ☐ Insert a jumper wire between J8 and A7 to connect IC pins 6 and 2
- ☐ Insert a 1K resistor between G8 and D8 to connect IC pins 6 and 3
- ☐ Insert a 1uf Capacitor between D6 and D7 taking care to orient the shorter ground lead into D6 and the longer positive lead into D7
- ☐ Insert a 22uf capacitor between C3 and C12 taking care to connect the shorter ground lead into C12
- ☐ Insert the speaker at D12 and D13
- ☐ Insert a jumper wire between E13 and I1
- ☐ Insert a jumper wire between G1 and A6
- ☐ Connect the battery to the battery clip
- ☐ Press the button.

Press the button to send messages encoded in Morse code. If the speaker does not beep when the button is pressed, double-check all of the above connections. Samuel F.B. Morse invented Morse code in 1844. It is used to encode information by sound, light or even vibration. Morse code is used to this day by Amateur Radio Operators.

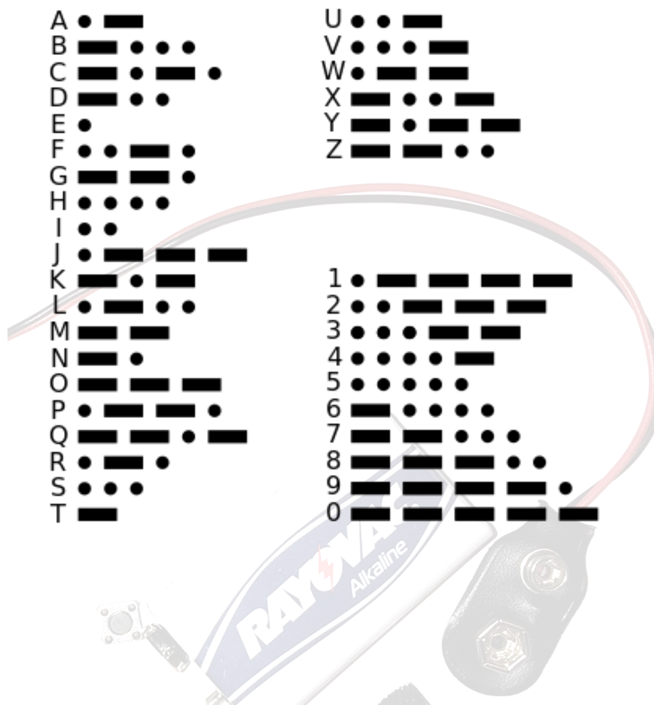
See next page for a Morse code reference.

Morse Code Guide

Every evil genius should know how to encode messages. It is possible to send messages using the International Morse Code.

International Morse code is composed of five elements:

1. Short mark, dot or "dit" (·) "dot duration" is one time unit long
2. Longer mark, dash or "dah" (–) three time units long
3. Inter-element gap between the dots and dashes within a character, one dot duration, or one unit long
4. Short gap (between letters) three time units long
5. Medium gap (between words) seven time units long



Morse Code was the original text messaging. Just as we use many abbreviations today when we text people like LOL (Laughing out loud) or ROFL (Rolling on the floor laughing) – lots of abbreviations emerged when people started to communicate using Morse code.

Common Morse Code Signals:

International Distress Signal - SOS - •••−−−•••

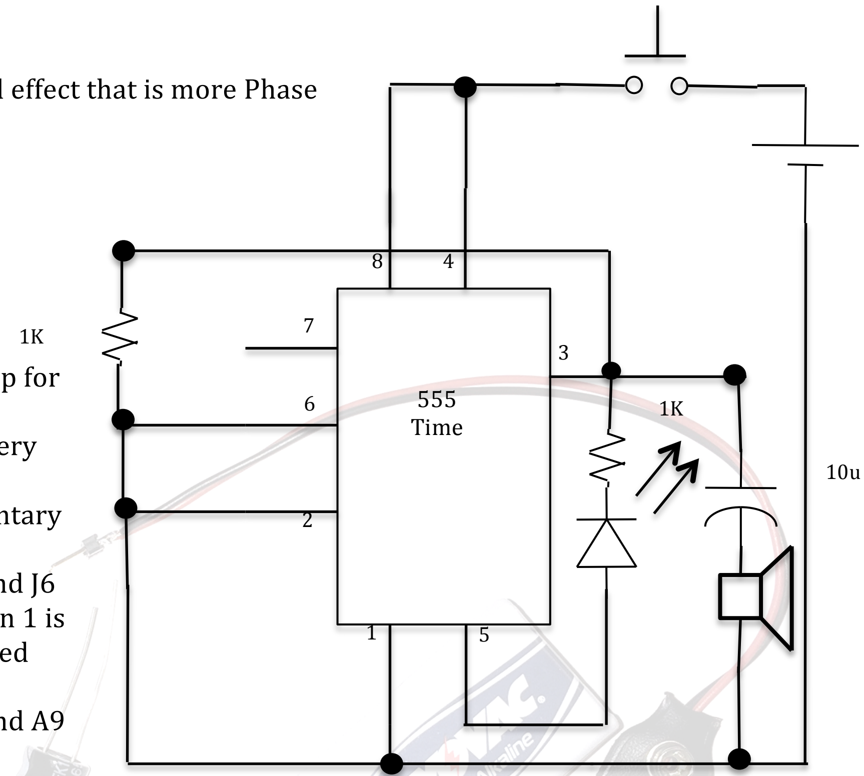
Seek you, a common way to say, "Calling any Station". – CQ - −•−• −−•−

"This is from"... - DE - −•• •

Be Seeing You – BCNU - −••• −•−• −• ••−

Experiment #6 – Laser Ray

This project makes a simple ray gun sound effect that is more Phase than Photon Torpedo.

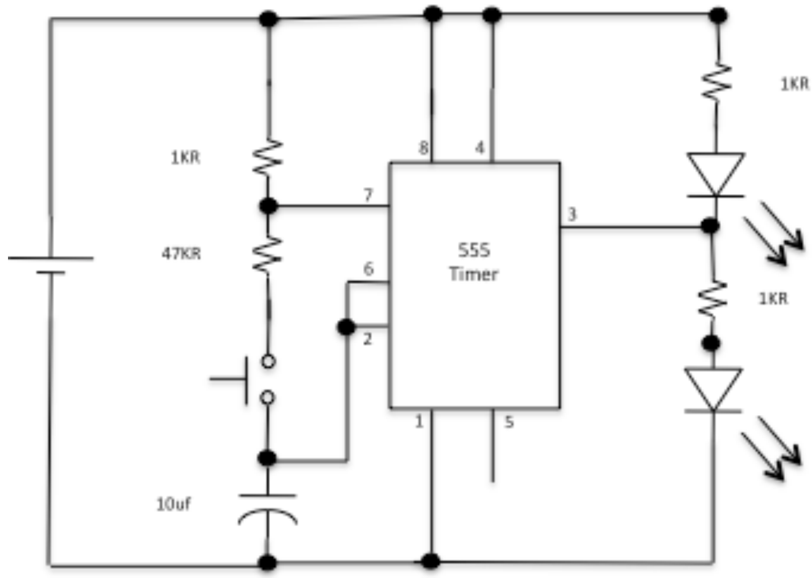


Construction Checklist

- ☐ Disconnect the battery from the clip for safety
- ☐ Connect the red lead from the battery clip to J2 and the black lead to J1
- ☐ Connect the four legs of the momentary switch to I2, I3, F2 & F3
- ☐ Insert a jumper wire between J4 and J6
- ☐ Insert the 555 timer oriented so Pin 1 is inserted into E6 and Pin 8 is inserted into F6
- ☐ Insert a jumper wire between I6 and A9 to connect IC pins 8 and 4
- ☐ Insert a jumper wire between J8 and A7 to connect IC pins 6 and 2
- ☐ Insert a 1K resistor between G8 and D8 to connect IC pins 6 and 3
- ☐ Insert a 10uf capacitor between C8 and C12 taking care to connect the shorter ground lead into C12.
- ☐ Insert the speaker at D12 and D13
- ☐ Insert a jumper wire between A13 and A6
- ☐ Insert a jumper wire between B6 and H1
- ☐ Insert a 1K resistor between A8 and A14
- ☐ Insert the longer Anode lead of an LED into B15 and the shorter Cathode lead into B14
- ☐ Insert a jumper wire between A15 and F9
- ☐ Connect the battery to the battery clip
- ☐ Press the button

The LED will light when the button is pressed and you will hear a ray gun sound. If the LED does not light when the button is pressed, double-check all of the above connections.

Experiment #7 - Reaction Timer



After building this circuit press the button and keep it pressed for several seconds until you get familiar with the operation of this clock. Once you are familiar with the operation, try releasing the button so that the light stops on green five times in a row.

If you find that it is too easy you can increase the difficulty by either replacing the 47KR with a 4.7KR - reducing the resistance will decrease the delay in the timer.

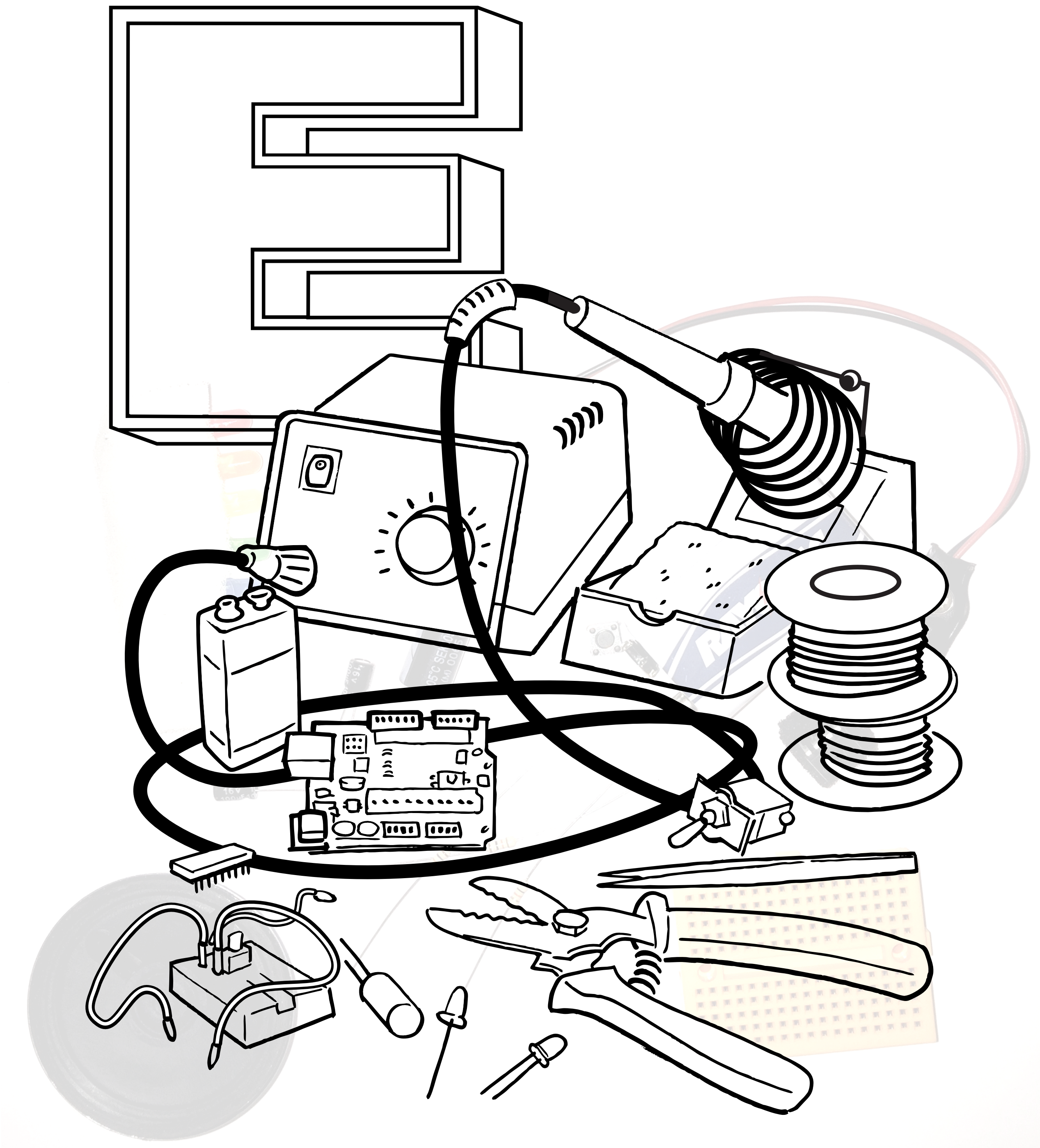
Another option is to keep the 47KR in place, remove the 10uf CAP in I16 and I17 with a 1uf in both I16 & I17 AND a 1uf in H16 and H17. Increasing the capacitance, or decreasing the resistance has the same effect – to reduce the time each LED is lit.

Construction Checklist

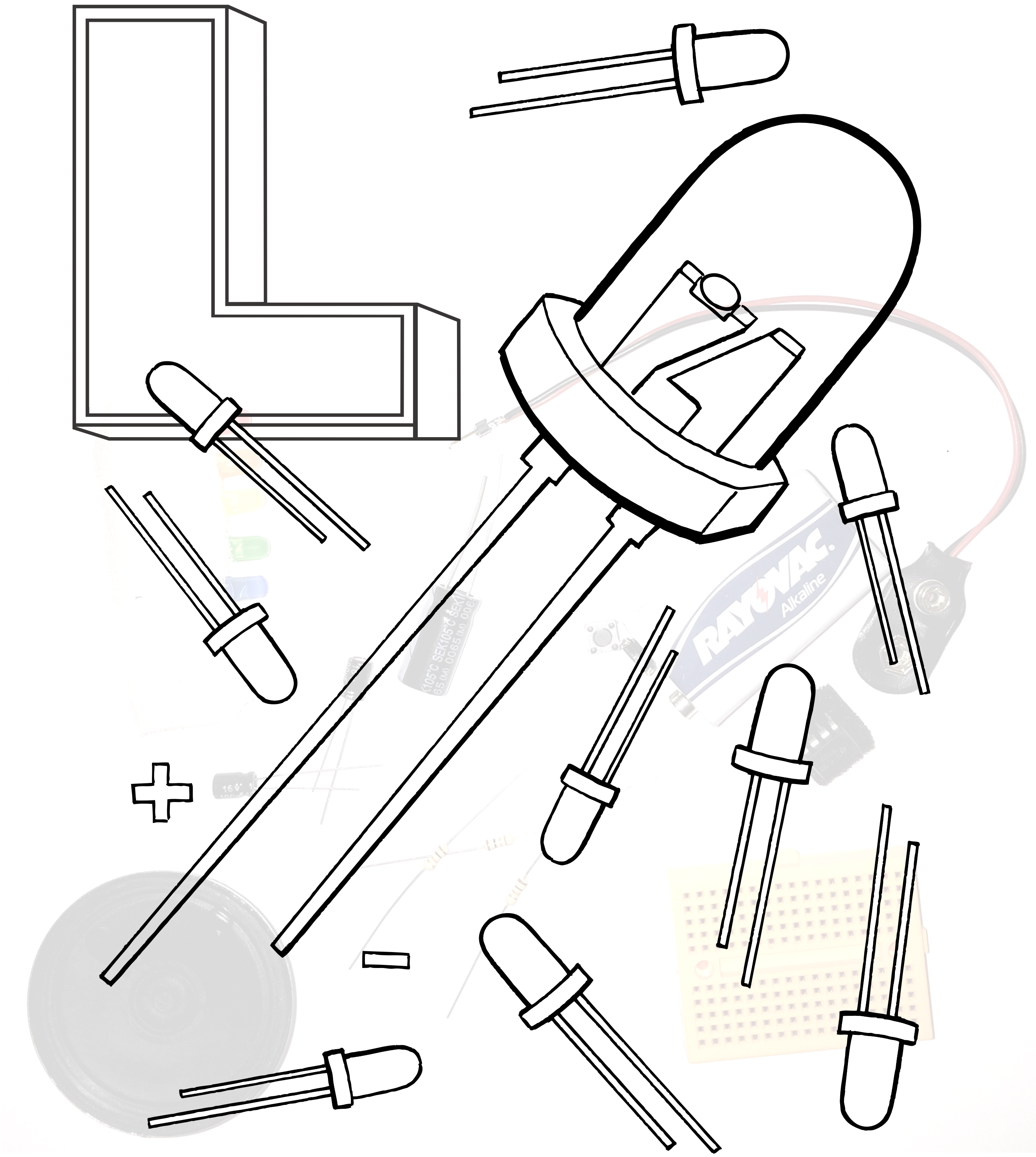
- ☐ Disconnect the battery from the clip for safety
- ☐ Connect the red lead from the battery clip to J2 and the black lead to J1
- ☐ Connect the four legs of the momentary switch to J11, J13, G11 & G13
- ☐ Insert the 555 timer oriented so Pin 1 is inserted into E6 and Pin 8 is inserted into F6
- ☐ Insert a 1K resistor between J6 and J7 to connect IC pins 7 and 8
- ☐ Insert a 1K resistor between A1 and A2
- ☐ Insert a 1K resistor between A15 and A16
- ☐ Insert a 47K resistor between G7 and F11
- ☐ Insert a 10uf capacitor between I16 and I17 taking care to connect the shorter ground lead into I17.
- ☐ Insert the longer Anode lead of a RED LED into B2 and the shorter Cathode lead into B3
- ☐ Insert the longer Anode lead of a GREEN LED into C16 and the shorter Cathode lead into C17
- ☐ Insert a jumper wire between I1 and J17 to connect the 10uf Capacitor to ground
- ☐ Insert a jumper wire between H2 and H6 to connect power to Pin 8 of the 555
- ☐ Insert a jumper wire between H8 and G16 to connect Pin 6 and 2 to the 10uf Capacitor
- ☐ Insert a jumper wire between F13 and F16 to connect the switch to the 10uf Capacitor
- ☐ Insert a jumper wire between F2 and E1 to connect power to a 1KR
- ☐ Insert a jumper wire between G1 and A6 to connect ground to Pin 1 of the 555
- ☐ Insert a jumper wire between G6 and A9 to connect Pin 8 to Pin 4 of the 555
- ☐ Insert a jumper wire between G8 and A7 to connect Pin 6 to pin 2 of the 555
- ☐ Insert a jumper wire between D6 and D17 to connect ground to the Green LED
- ☐ Insert a jumper wire between A8 and B15 to connect Pin 3 to the RED LED
- ☐ Insert a jumper wire between A3 and B8 to connect Pin 3 to the RED LED
- ☐ Connect the battery to the battery clip
- ☐ Press the button

Coloring Book Excerpts From Lady Ada’s “E is for Electronics”

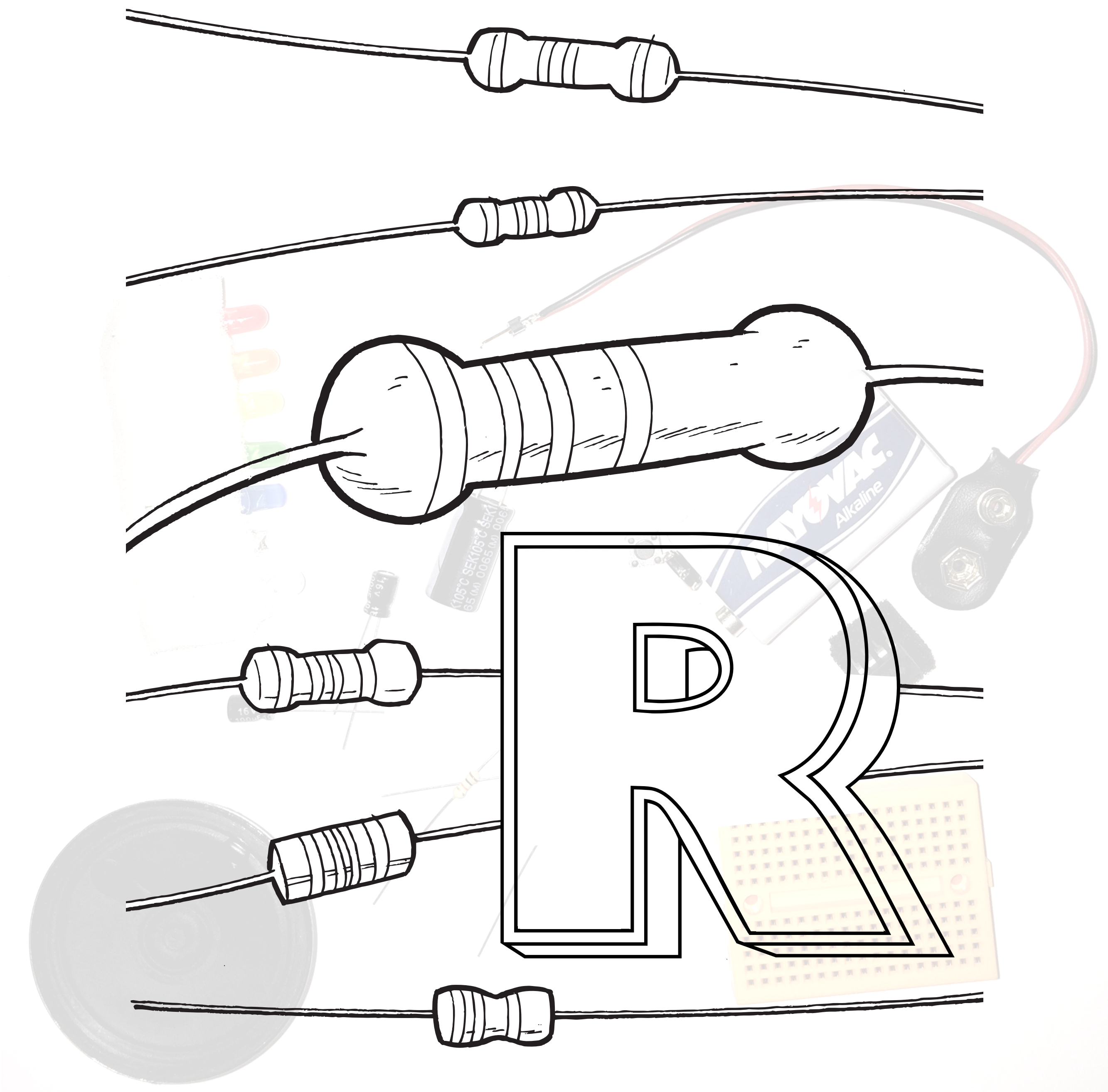
A **capacitor** stores electrons using an electric field. The **capacitor** has two separated plates, where electrons are held. A voltage placed across the **capacitor** makes the electrons want to move from one plate to the other, but a 'dielectric' between the plates is there to make sure that they don't. The electrons can be stored on the plates until they are needed to make a circuit. **Ewald Georg von Kleist** made one of the first capacitors.



Electronic devices work by moving **electrons** around to light up video games and power cell phones. **Electrical engineers** like Ladyada design **electronics** using batteries, capacitors, diodes, LEDs, transistors, and integrated circuits. By combining all these parts in new and clever ways, **engineers** can make the wonderful new devices you use every day.



An **LED (light-emitting diode**) is a special kind of diode that emits light when a current flows through it. The **LED** has two terminals, an anode and a cathode. Because it is a diode, electrons can only flow in one direction. When the electrons cross the barrier between the anode and the cathode, they release a photon, which produces light.



A **resistor** controls the flow of electrons through a circuit by letting only a certain number of electrons go through the circuit per second. Any extra electrons that try to get through must wait in line. The colored stripes let you know how many electrons can go through the **resistor** at the same time.

Links to more

If you have enjoyed working with the projects in this kit, then be mindful of the fact there is a world of electronic proejcts that live online. The Internet brings a wealth of projects ad knowledge to anyone interested in looking for them. Here are some of the resources we found while preparing this manual.

Project Ideas

Circuit Digests 555 Timer Projects
http://circuitdigest.com/555-timer-circuits

555 Timer Circuits
http://www.555-timer-circuits.com/

47 Projects to do with the 555
http://www.instructables.com/id/47-projects-to-do-with-a-555/

555 Timer Weekend Projects Make Magazine
http://makezine.com/2012/08/24/555-timer-weekend-projects/

The 555 Precision Timer IC
http://tronixstuff.com/2011/01/27/the-555-precision-timer-ic/

Parts Vendors

All Electronics
http://www.allelectronics.com/

Adafruit Industries
http://www.adafruit.com/

Digi-Key
https://www.digikey.com/

MCM Electronics
http://www.mcmelectronics.com

Mouser Electronics
http://www.mouser.com/

Spark Fun
http://www.sparkfun.com/

1 Pound Electronics Grab Bags
https://www.jameco.com/z/GB191LB-1-Pound-Miscellaneous-Electronic-Component-Grab-Bag_135263.html